



DUKE COGEMA
STONE & WEBSTER

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Washington, DC 20555

28 July 2003
DCS-NRC-000150

Subject: Docket Number 070-03098
Duke Cogema Stone & Webster
Mixed Oxide (MOX) Fuel Fabrication Facility
Construction Authorization Request Change Pages and Revised Response to
AP-03

References: 1) P. S. Hastings (DCS) to Document Control Desk (NRC), *Docket Number 070-03098 Duke Cogema Stone & Webster Mixed Oxide (MOX) Fuel Fabrication Facility Construction Authorization Request Change Pages*, DCS-NRC-000132, 10 April 2003

Enclosed are change pages for Duke Cogema Stone & Webster's (DCS) request for authorization of construction of the Mixed Oxide (MOX) Fuel Fabrication Facility. The enclosed change pages replace pages in the Construction Authorization Request as updated through Reference 1.

The enclosed change pages do not contain information which is considered to be proprietary to DCS. Enclosure 1 provides twenty-five copies of the change pages, which may be disclosed to the public. Enclosure 2 provides the page replacement instructions.

The changed pages are the result of additional clarifications to Draft Safety Evaluation Report (DSER) Open Items.

Also included as Enclosure 3 is the revised response for open item AP-3.

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If I can provide any additional information, please feel free to contact me at (704) 373-7820.

Sincerely,

For 

Peter S. Hastings, P.E.
Manager, Licensing and Safety Analysis

- Enclosures:
- 1) Change Pages to the Mixed Oxide Fuel Fabrication Facility Construction Authorization Request (non-proprietary)
 - 2) Construction Authorization Request 07/28/03 Update Instructions
 - 3) Revised Response to DSER Open Item AP-03

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Enclosure 1

**Change Pages for Mixed Oxide Fuel Fabrication Facility
Construction Authorization Request
(non-proprietary)**

25 copies enclosed

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Table 5.5-12. Mapping of Hazard Assessment Events to Fire Event Groups

Event Group	General Event Description	Hazard Assessment Events
AP Process Cells	Fires in fire areas within the AP process cells	AP-4*, AP-3, AP-40, HV-17
AP/MP C3 Glovebox Areas	Fires in fire areas in the AP or MP Areas.	GB-1*,RC-4, PW-1, PT-1, PT-2, AP-5, RD-2, RD-3, AP-2, MA-1, AP-1, WH-2, PT-3, GB-2, WH-1
C1 and/or C2 Areas - 3013 Canister	Fire involving 3013 canisters	RC-1*
C1 and/or C2 Areas – Fuel Rod	Fire involving fuel rods or assemblies	AS-1* AS-2, RD-1
C1 and/or C2 Areas - 3013 Transport Cask	Fire involving 3013 transport casks	RC-3*
C1 and/or C2 Areas - MOX Fuel Transport Cask	Fire involving MOX fuel transport cask	AS-11*
C1 and/or C2 Areas - Transfer Container	Transfer containers involved in a fire outside of a C3 area	MA-2*
C1 and/or C2 Areas - Waste Container	Waste Containers involved in a fire	AS-13*, MA-12, RC-16
C1 and/or C2 Areas - Final C4 HEPA filter	Fires involving the areas containing the final C4 HEPA filters	HV-1*
Outside MOX Fuel Fabrication Building	Fires originating outside of the MOX Fuel Fabrication Building	SF-1*, GH-13
Facilitywide Systems	Fires involving systems that cross fire areas	FW-2*, HV-2
Facility	Fire involving more than one fire area	FW-1*

* Hazard assessment event with bounding consequences for this event group.

Table 5.5-13a. Fire Event - Summary of Principal SSCs - Facility Worker

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are highly unlikely
AP/MP C3 Glovebox Areas	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
	Facility Worker Controls	Ensure that facility workers take proper actions prior to maintenance activities to limit radiological exposure.
	Maintenance Activity Controls	Isolation of power to the electrolyzer when the electrolyzer is drained
	Process Safety Control Subsystem	Monitor the electrolyzer for electrical faults that could result in arcing or other imparting of electrical energy with the risk of titanium fire
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Waste Container	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.

Table 5.5-13a. Fire Event - Summary of Principal SSCs - Facility Worker (continued)

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - Transfer Container	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing transfer containers to ensure that the containers are not adversely impacted by a fire.
C1 and/or C2 Areas - Final C4 HEPA Filter	Combustible Loading Controls	Limit the quantity of combustibles in the filter area to ensure that the final C4 HEPA filters are not adversely impacted by a fire in the filter room.
Outside MOX Fuel Fabrication Building	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	Waste Transfer Line	Prevent damage to line from external fires.
Facilitywide Systems	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing a pneumatic system to ensure that this system is not adversely impacted by a fire.
Facility	Fire Barriers	Contain fires within a single fire area
	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.

Table 5.5-13b. Summary of Principal SSCs for Environmental Protection From Fire Events

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are unlikely.
AP/MP C3 Glovebox Areas	C3/C4 Confinement Systems	Remain operable during design basis fire and effectively filter any release.
	Fire Barriers	Contain/limit fires to a single fire area
	Combustible Loading Controls [For Storage Gloveboxes ONLY]	Limit the quantity of combustibles in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material.
	Maintenance Activity Controls	Isolation of power to the electrolyzer when the electrolyzer is drained
	Process Safety Control System	Monitor the electrolyzer for electrical faults that could result in arcing or other imparting of electrical energy with the risk of titanium fire
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.

Table 5.5-13b. Summary of Principal SSCs for Environmental Protection From Fire Events (continued)

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing transfer containers to ensure that the containers are not adversely impacted by a fire.
C1 and/or C2 Areas - Final C4 HEPA Filter	Combustible Loading Controls	Limit the quantity of combustibles in the filter area to ensure that the C4 final HEPA filters are not impacted by a filter room fire.
Outside MOX Fuel Fabrication Building	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	Waste Transfer Line	Prevent damage to line from external fires.
Facility Wide Systems	Combustible Loading Controls	Limit the quantity of combustibles in areas containing the pneumatic transfer system to ensure this system is not adversely impacted
Facility	Fire Barriers	Contain fires within a single fire area

Table 5.5-14. Fire Event - Summary of Principal SSCs - Public and Site Worker

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are highly unlikely
AP/MP C3 Glovebox Areas	C3/C4 Confinement Systems	Remain operable during design basis fire and effectively filter any release.
	Fire Barriers	Contain/limit fires to a single fire area
	Combustible Loading Controls [For Storage Gloveboxes ONLY]	Limit the quantity of combustibles in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material.
	Maintenance Activity Controls	Isolation of power to the electrolyzer when the electrolyzer is drained
	Process Safety Control Subsystem	Monitor the electrolyzer for electrical faults that could result in arcing or other imparting of electrical energy with the risk of titanium fire
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask ^a	Withstand the design basis fire without breaching.
	Combustible Loading Controls ^a	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.

**Table 5.5-14. Fire Event - Summary of Principal SSCs - Public and Site Worker
(continued)**

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	None Required	N/A
C1 and/or C2 Areas - Final C4 HEPA Filter	Combustible Loading Controls ^a	Limit the quantities of combustibles in the filter area to ensure that the C4 final HEPA filters are not impacted by a filter room fire.
Outside MOX Fuel Fabrication Building	Waste Transfer Line	Prevent damage to line from external fires.
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
Facilitywide Systems	None Required	N/A
Facility	Fire Barriers	Contain fires within a single fire area

^a Required for site worker only

Table 5.5-15. Mapping of Hazard Assessment Events to Load Handling Event Groups

Event Group	Event Description	Hazard Assessment Event
AP Process Cells	Load Handling Events within an AP Process Cell	AP-27*, AP-43
AP/MP C3 Glovebox Areas	Load Handling Events in C3b/glovebox areas	PT-10, GB-8, GB-9*
C1 and/or C2 Areas – 3013 Canister	Load Handling Events within the C2 areas involving 3013 canisters	RC-12*
C1 and/or C2 Areas - 3013 Transport Cask	Load Handling Events involving 3013 Transport Cask	RC-17*
C1 and/or C2 Areas – Fuel Rod	Load Handling Events in the C2 areas involving fuel rods.	AS-7*, AS-9, RD-10
C1 and/or C2 Areas - MOX Fuel Transport Cask	Load Handling Event involving MOX Fuel Cask	AS-14*
C1 and/or C2 Areas - Waste Container	Loading Handling events in the C2 areas involving Waste Containers	AS-12*, MA-11, RC-15, WH-8
C1 and/or C2 Areas – Transfer Containers	Load Handling Events in the C2 areas involving Transfer Containers	FW-20*
C1 and/or C2 Areas - Final C4 HEPA Filter	Load Handling Events involving the final C4 HEPA filters	HV-15*
C4 Confinement	Leaks or spills within a glovebox	AP-36, GB-10*, RC-7
Outside MOX Fuel Fabrication Building	Load handling events occurring outside the AP/MP Buildings	SF-14*
Facilitywide	Load Handling Events that impact and damage the internal or external MFFF structure	FW-15*, FW-21, RC-13, HV-14, AS-8, RD-9, FW-17

* Hazard assessment event with bounding consequences for this event group.

5.6.2.6 Facility Worker Action

Where events are obvious to a facility worker and the worker has time to respond by taking self-protecting action, that action is credited in mitigating radiological or chemical consequences to the worker. Section 5.5 identifies several events that may require facility workers to evacuate the room where an event occurs.

Execution of training/qualification programs and the use of procedures are part of the qualitative demonstration of likelihood with respect to a facility worker's actions to protect themselves (e.g., by evacuation). In such circumstances, the facility worker will be aware of the event, and take appropriate action to minimize radiological or chemical exposures.

Worker actions to take self-protection measures are credited in certain scenarios. Much of the training and procedures that constitute management measures in support of these worker actions are provided under the health physics program. The health physics program is established as good management practice for a facility such as this, and pursuant to 10 CFR 20; it also provides for maintaining exposures ALARA, and provides additional protection features in support of worker safety. Continuous air radiation monitors are positioned close to work locations and within the ventilation air flow from potential release points. This feature provides additional assurance of an immediate response to a confinement failure. Other fixed air monitors are positioned within the process room for general surveillance. Monitors are designed for extremely high plutonium alpha radiation sensitivity – activity as low as 4 DAC-hours is detected (equivalent to doses in the range of a few millirem). Gloves are routinely surveyed for contamination. Gloves are also replaced frequently to prevent loss of confinement due to glove degradation. All workers are provided with respirators that are designed to filter plutonium particulate. The health physics program, including appropriate training with respect to worker evacuation, the use of respirators, etc., is a management measure that supports the principal SSC of worker actions for self-protection. The health physics program would also control activities associated with the longer-term response to and recovery from events to ensure that exposures are maintained within appropriate limits. The basic elements of the program are summarized in Section 9.2 of the CAR.

5.6.2.7 Laboratory Material Controls

Laboratory material controls consist of administrative procedures that will be used to control the quantity of radiological and chemical materials in the laboratory. The safety function of the laboratory material controls program is to limit the extent of any potential explosion by limiting the quantity of hazardous chemicals that may be involved in the explosion and to limit the quantity of radiological/chemical material available for dispersion following a potential explosion.

Procedures will be developed to establish limits on sample size, the number of samples that may be stored and used in the laboratory overall and in any one laboratory location, and the quantity of chemicals, reagents or other hazardous materials that may be stored and used in a laboratory. Procedures will also be developed to ensure laboratory operations are performed in accordance with safe laboratory operating practices.

5.6.2.8 Hazardous Material Delivery Controls

The safety function of hazardous material delivery controls is to ensure that the quantity of delivered hazardous material and its proximity to the MOX Fuel Fabrication Building structure, Emergency Generator Building structure, and the waste transfer line are controlled to within the bounds of the values used to demonstrate that the consequences of outside explosions are acceptable.

5.6.2.9 Facility Worker Controls

The principal SSC facility worker controls credit the facility worker with taking proper actions prior to commencing an activity that could result in an event with unacceptable dose consequences. This differs from the principal SSC facility worker action where the facility worker is credited with taking self-protective measures to minimize dose consequences as a result of an event. Precautions associated with the radiation protection program (such as the use of a mask) are implemented prior to beginning operations involving, or potentially near to, primary confinements thereby ensuring the facility worker is protected in case radioactive material is released.

Specifically, in cases where the facility worker is performing a task with transient primary confinements within C3 areas (e.g., during bagout operations), facility worker controls ensure that facility workers take proper actions prior to commencing bag-out operations to prevent and/or limit their dose. Additionally, facility workers take proper actions prior to commencing maintenance activities in AP/MP C3 Areas to prevent and/or limit their exposure.

Similar to facility worker actions, many of the procedures and training that constitute management measures in support of these facility worker controls are provided under the health physics program. These measures provide a basis for the good planning of work tasks associated with the aforementioned activities. The health physics program is established as good management practice for a facility such as this, and pursuant to 10 CFR 20; it also provides for maintaining exposures ALARA, and provides additional protection features in support of worker safety. The basic elements of the program are summarized in Section 9.2 of the CAR.

5.6.2.10 Maintenance Activity Controls

The principal SSC maintenance activity credits the facility worker with taking the proper actions to ensure the isolation of the power to the electrolyzer when the electrolyzer is drained. Procedures will be developed and incorporated with the maintenance activity procedures to establish necessary guidelines for processes involving the welding of process vessels containing titanium

5.6.3 Sole Principal IROFS

A list identifying IROFS that are the sole item preventing or mitigating an accident sequence whose risk could exceed the performance requirements of 10 CFR §70.61 will be provided in the ISA Summary submitted with the license application for possession and use of SNM.

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Process Safety Control Subsystem (continued)	Control the flowrate into the oxidation column	8.5
	Ensure the temperature of solutions containing organic is restricted to temperatures within safety limits in order to limit the rate of energy generation	8.5
	Limit the residence time of organics in process vessels containing oxidizing agents and potentially exposed to high temperatures and in radiation fields	8.5
	Ensure the temperature of solutions potentially containing hydrazoic acid is limited to prevent an explosive concentration of hydrazoic acid from developing	8.5
	Limit and control conditions under which dry-out can occur	8.5
	Ensure the temperature of solutions potentially containing metal azides is insufficient to overcome the activation energy needed to initiate the energetic decomposition of the azide	8.5
	Ensure the normality of the nitric acid is sufficiently high to ensure that the offgas is not flammable and to limit excessive hydrogen production	8.5
	Warn operators of glovebox pressure discrepancies prior to exceeding differential pressure limits	11.4.11
	Shut down process equipment prior to exceeding temperature safety limits	11.4.11
	Ensure the temperature of solutions containing solvents is limited to temperatures within safety limits	8.5
	Ensure the flow rate of nitrogen dioxide/dinitrogen tetroxide is limited to the oxidation column of the purification cycle	8.5
	Maintain sintering furnace within design limits	11.4.11

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Process Safety Control Subsystem (Continued)	Monitor the electrolyzer for faults that could result in arcing or other imparting of electrical energy with the risk of initiation of titanium fire	11.6.7 System Description – 11.3.2.4
Seismic Monitoring System and Associated Seismic Isolation Valves	Prevent fire and criticality as a result of an uncontrolled release of hazardous material and water within the MFFF Building in the event of an earthquake	11.6.7 – for system 11.8.7 – for valves
Sintering Furnace	Provide a primary confinement boundary against leaks into C3 areas	11.4.11
Supply Air System	Provide unconditioned emergency cooling air to the storage vault and designated electrical rooms	11.4.11
Transfer Container	Withstand the effects of design basis drops without breaching	11.4.11
Waste Containers	Ensure that hydrogen buildup in excess of limits does not occur while providing appropriate confinement of radioactive materials	11.4.11
Waste Transfer Line	Ensure that the waste transfer line is protected from activities taking place outside the MOX Fuel Fabrication Building	10.5
	Prevent damage to the line from external fires, explosions, earthquakes, extreme winds, tornadoes, missiles, rain, and snow and ice loadings	10.5

* Administrative control

Table 5A-2. Unmitigated Events, Aqueous Polishing (continued)

Event Type/Workshop or Location/ Event Number	Unmitigated Event Description/Specific Location/Hazard Sources	Cause
<p>Explosion</p> <p>Aqueous Polishing</p> <p>AP-39</p> <p>E-2</p>	<p>A process-related chemical explosion involving red oil formation (nitrates or nitric acid solutions of heavy metals and TBP at temperatures in excess of 133 C) in AP boiler, vessel, or tank (in AP process cell or glovebox) results in an energetic breach of the AP boiler, vessel, or tank and the Loss of Confinement / Dispersal of Nuclear Materials.</p> <p>Specific Location:</p> <p>AP-Purification cycle AP-Solvent recovery AP-Acid recovery AP-Liquid Waste Reception AP-Precipitation-Filtration-Oxidation AP-Oxalic mother liquors recovery</p> <p>Mode: All</p> <p>Hazard Sources:</p> <p>Radiological Material (maximum inventory in AP vessels, tanks and piping)</p>	<p>1. Temperature above 133 C in boiler, vessel, or tank and presence of nitrates or nitric acid solutions of heavy metals and TBP</p>
<p>Explosion</p> <p>Aqueous Polishing</p> <p>AP-44</p> <p>E-2</p>	<p>A process-related chemical explosion involving an azide (other than hydrazoic acid) in an AP boiler, vessel, or tank (in an AP cell or glovebox) results in an energetic breach of the AP boiler, vessel, or tank and the Loss of Confinement / Dispersal of Nuclear Materials.</p> <p>Specific Location:</p> <p>AP-Purification cycle AP-Solvent recovery AP-Liquid Waste Reception</p> <p>Mode: All</p> <p>Hazard Sources:</p> <p>Radiological Material (maximum inventory in AP vessels, tanks and piping)</p>	<p>1. Temperature above 133 C in boiler, vessel, or tank and presence of azide solutions.</p>

Table 5A-2. Unmitigated Events, Aqueous Polishing (continued)

Event Type/Workshop or Location/ Event Number	Unmitigated Event Description/Specific Location/Hazard Sources	Cause
<p>Explosion</p> <p>Aqueous Polishing</p> <p>AP-47</p> <p>E-2</p>	<p>Electrolysis-induced hydrogen buildup in the vapor space of an electrolyzer results in a hydrogen explosion and the dispersal of radiological materials.</p> <p>Specific Location:</p> <p>AP-Dissolution AP-Dissolution of chlorinated feed</p> <p>Mode: All</p> <p>Hazard Sources:</p> <p>Radiological Material (maximum inventory in AP vessels, tanks and piping)</p>	<ol style="list-style-type: none"> 1. Incorrect chemical handling 2. Incorrect reagent preparation 3. Hydrogen or other explosive gas released due to incompatible chemical addition errors 4. Explosive gas and electrical short 5. Explosive gas and unknown ignition source
<p>Explosion</p> <p>Aqueous Polishing</p> <p>AP-48</p> <p>E-2</p>	<p>A process-related chemical explosion involving plutonium (VI) in the calcining furnace results in an energetic breach of the furnace and glovebox and the dispersal of radiological materials.</p> <p>Specific Location:</p> <p>AP-Precipitation-Filtration-Oxidation</p> <p>Mode: All</p> <p>Hazard Sources:</p> <p>Radiological Material (maximum inventory in AP vessels, tanks and piping)</p>	<ol style="list-style-type: none"> 1. Incorrect chemical handling 2. Incorrect reagent preparation 3. Hydrogen or other explosive gas released due to incompatible chemical addition errors 4. Explosive gas and electrical short 5. Explosive gas and unknown ignition source
<p>Explosion</p> <p>Aqueous Polishing</p> <p>AP-49</p> <p>E-2</p>	<p>A process-related chemical explosion involving liquid addition to the calcining furnace results in an energetic breach of the furnace and glovebox and the dispersal of radiological materials.</p> <p>Specific Location:</p> <p>AP-Precipitation-Filtration-Oxidation</p> <p>Mode: All</p> <p>Hazard Sources:</p> <p>Radiological Material (maximum inventory in AP vessels, tanks and piping)</p>	<ol style="list-style-type: none"> 1. Corrosive chemicals interact with vessels/piping/ associated equipment 2. Incorrect chemical handling 3. Incorrect reagent preparation 4. Temperature of chemical(s) above flashpoint 5. Hydrogen or other explosive gas released due to incompatible chemical addition errors 6. Explosive gas and electrical short 7. Explosive gas and unknown ignition source

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6.3.3.2.12 Process Variable Control

Process variable control involves taking credit for process conditions maintained within fissile systems, including bounding normal operational tolerances on process parameters and abnormal accident conditions. Process variables can involve any of the other 11 control modes, as well as the physical and chemical forms of the fissile material. Process variable control inherently requires some reliance on active engineered features and is thus less desirable than passive controls (e.g., geometry control) or worst-case process variable assumptions in terms of hierarchical preference. Justification for the use of process variable control is provided in NCSEs and the ISA Summary.

Process variable control parameter limits are established and implemented as follows:

- SSCs or procedures that control the parameters necessary to ensure that the process variables relied on for criticality safety are identified as IROFS in NCSEs and the ISA Summary and are subject to facility QA measures sufficient to ensure that the associated controlled parameter safety limit is not exceeded.

6.3.4 Criticality Safety Process Description

6.3.4.1 Overview

Criticality hazards arise from the handling and processing of fissionable materials in the MFFF. Such hazards could result in a criticality event leading to dispersal of radioactive material and/or direct exposure of nearby personnel.

In the AP process, fissile material is present in both solid form (plutonium oxide powder, plutonium oxalate precipitate) and liquid form (plutonium nitrate). In the MP process, fissile material is present as plutonium oxide powder, uranium oxide powder, MOX powders with different plutonium contents (master blend, final blend), pellets, rods, and assemblies.

The criticality risk is due primarily to the fissile isotope ^{239}Pu , although the presence of other fissile isotopes (present in small quantities) is also considered.

6.3.4.2 Applicable Safety Principles

The MFFF is designed such that the risk of nuclear criticality accidents is limited by assuring that under normal and credible abnormal conditions, all nuclear processes are subcritical, including use of an approved margin of subcriticality for safety. This goal is primarily achieved through adherence to the double contingency principle as stated in ANSI/ANS-8.1-1983 (R1988).

The objective of criticality safety analysis is to demonstrate that the risk of a criticality event is acceptably low based on consideration of the following:

- Highly reliable facility design features capable of withstanding applicable internal and external hazard events

- Management measures implemented during normal operating conditions
- Implementation of corrective action to avoid exceeding design limits in the event of a malfunction.

Specific safety principles incorporated during the development of the MFFF design in order to enhance the inherent reliability of criticality controls are summarized as follows: (a) the preferred use of passive engineered features over active engineered features, (b) the preferred use of engineered features over administrative controls, (c) the preferred use of enhanced administrative controls over simple administrative controls, and (d) where practical, the use of two-parameter control over single parameter control¹.

6.3.4.3 General Design Approach

The design approach with respect to criticality is as follows:

- Separate the facility into criticality control units (usually based on process units or areas)
- For each criticality control unit:
 - Identify the physical and chemical (i.e., physicochemical) forms of the fissile medium in the unit
 - Define the criticality control method(s) and applicable controlled parameter(s)
 - For each controlled parameter:
 - Assume the credible optimal condition (i.e., most reactive condition physically possible) for the parameter, or
 - Calculate the allowed range for the parameter.
 - Specify controls to be implemented to limit controlled parameter(s) to the specified allowable range of values
 - Demonstrate compliance with the double contingency principle.

Controls implemented to limit controlled parameters within an allowable range of values can involve engineered design features and/or management measures. Compliance with the double contingency principle will be demonstrated for normal and credible abnormal conditions.

¹ Two-parameter control inherently incorporates diverse forms of control, which generally result in higher levels of control reliability than single-parameter control. However, such a criticality control scheme incorporating the preferred MFFF hierarchy of criticality controls typically is not feasible for the MFFF owing to assumed Pu-239 content. Therefore, the MFFF design preference is to rely on passive geometry control as the preferred criticality safety control, followed by reliance on dual independent controls on control parameters. The preference for use of two-parameter control is maintained in the hierarchy of preferred controls for consideration in the event of changes in design where two-parameter control could be feasible.

6.3.4.3.1 Physical and Chemical Forms

Control of physicochemical characteristics is applied to several AP process units where non-optimal solution chemistry or specific values for some parameters (e.g., pellet diameter) are used in the definition of the fissile media and are assumed in criticality design calculations.

The physicochemical form of the fissile material is defined by the following:

- Its chemical composition
- The pellet diameter (if applicable)
- The rod characteristics (if applicable)
- The assembly characteristics (if applicable).

Note: Other characteristics (e.g., density) could be considered as being part of the physicochemical characteristics, but they are listed as control modes (in Section 6.3.4.3.2). The various physicochemical forms for the MFFF processes are described in the following sections. The isotopic composition of the fissile material, including impurities, is discussed in Section 6.3.4.3.2.4.

6.3.4.3.1.1 Chemical Form

In the MP process, no chemical transformations take place. As a consequence, the oxide form of the fissile medium (PuO_2 or UO_2 , as applicable) is always assumed.

For the AP process, a conservative assumption concerning the chemical form of the fissile matter is made for each step of the process, taking into account not only the nominal conditions but also the possible process upsets (e.g., failure of a PuO_2 filter or unwanted soda introduction that may cause precipitates) defined based on the double contingency principle. The different chemical forms used in the criticality analyses are as follows:

- PuO_2
- $\text{Pu}(\text{NO}_3)_4$
- $\text{Pu}(\text{NO}_3)_3$
- Plutonium oxalate.

6.3.4.3.1.2 Pellet Diameter (MP Process)

In some cases, the reference fissile medium is an array of pellets. In such cases, the pellet diameter is part of the definition of the reference fissile medium (as well as the pellet density and the plutonium content).

Note: For broken pellets, fragments, and grinding dust, the diameter of the original pellet is not controlled. Instead, bounding assumptions are used to evaluate the material.

The process values for pellets are as follows:

- Green standard pellets: 9.5 mm to 11.5 mm (estimated value)
- Sintered standard pellets: 7.9 mm to 9.6 mm (estimated value)

- Ground standard pellets: 7.84 mm to 9.49 mm (nominal value)
- Green recycled-scrap pellets: 12.6 mm (estimated value)
- Sintered recycled-scrap pellets: 10.49 mm (nominal value).

Depending on the type of products that are likely to be contained or handled by each unit (i.e., green or sintered pellets, standard pellets, or recycled-scrap pellets), including those in an off-normal situation as defined by the safety analysis, the appropriate range of diameters is studied in the criticality calculations.

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6.3.4.3.1.3 Rod Characteristics (MP Process)

In some cases, the reference fissile medium is an array of rods. In such a case, the rod geometry and material are part of the definition of the reference fissile medium (as well as the pellet density and the plutonium content).

The nominal values are as follows:

- Pellet diameter: 7.84 mm to 9.49 mm (standard ground pellet)
- Clad material: M5 zircalloy or zircalloy-4
- Clad thickness: 0.571 mm to 0.635 mm
- Clad outer diameter: 9.14 mm to 10.9 mm
- Active fuel stack height: 3,614 mm to 3,658 mm.

These parameters are important to the final product. The impact of a variation of these parameters on the calculated effective neutron multiplication factor (k_{eff}) will be justified based upon the criticality calculations and evaluated by the NCSEs.

6.3.4.3.1.4 Assembly Characteristics (MP Process)

In some cases, the assembly geometry is part of the definition of the reference fissile medium (as well as the rod characteristics and the plutonium content).

The process values are as follows:

- Number of rods: 204 to 264
- Rod lattice arrangement: 15×15 or 17×17
- Rod pitch: 12.60 mm to 14.43 mm.

These parameters are important to the final product. The impact of a variation of these parameters on the calculated effective neutron multiplication factor (k_{eff}) will be justified based upon the criticality calculations and evaluated by the NCSEs.

6.3.4.3.2 Choice of the Criticality Control Mode

Criticality safety in the MFFF is ensured by application of one or more of the following control modes, as well as by the control of the physicochemical forms of the fissile material (see Section 6.3.4.3.1):

- Geometry control
- Mass control
- Density control
- Isotopics control
- Reflection control
- Moderation control
- Concentration control
- Interaction control

Atmospheric Relative Concentrations in Building Wakes) code to obtain an airborne concentration. To calculate airborne concentrations for other chemicals affecting the site worker, source terms were generated using the same five-factor formula described above. These values were then multiplied by the 100-meter atmospheric dispersion factor (χ/Q) from the ARCON96 code. For chlorine and NO_x releases, release rates were obtained from chemical flow balances for the units where these chemicals are generated from SNM. The applied release rates do not credit the process scrubbers installed to remove a majority of these chemical by-products.

8.3.3.1 Dispersion Modeling

ALOHA is a time-dependent model that treats neutral or heavy gases and a variety of time-dependent sources, including broken pipes, leaking tanks, and evaporating puddles, modeled in consideration of atmospheric turbulence, entrainment, advection, and gravitational spreading. It is the preferred model for calculating chemical concentrations at distances approaching the CAB. The ALOHA computer code was verified and validated prior to its use for the evaluation of MFFF bounding chemical release consequences.

There are two discrete dispersion models in ALOHA: *Gaussian* and *heavy gas*. The Gaussian model was used for determining chemical concentrations at the CAB involving evaporative releases, as it yields conservative results for the applicable scenarios. The Gaussian model predicts dispersion of *neutrally buoyant gases* that have about the same density as air. Wind and atmospheric turbulence move the released gas through the air so that an escaped cloud is blown downwind, with "turbulent mixing" causing it to spread out in the crosswind and upward directions. A graph of gas concentration within any crosswind slice of a moving pollutant cloud looks like a bell-shaped curve, high in the center (where concentration is highest) and lower on the sides (where concentration is lower). At the point of a release, the pollutant gas concentration is very high, since the gas has not diffused very far in the crosswind and upward directions. A concentration graph in a crosswind slice of the cloud close to the source is a spike. As the pollutant cloud drifts farther downwind, it spreads out and the "bell shape" becomes wider and flatter.

MACCS simulates the accidental release of a plume of radiological materials to the atmosphere and estimate consequences associated with the release. The dispersion model in MACCS2 treats atmospheric transport and dispersion of material utilizing a Gaussian plume model with Pasquill-Gifford dispersion parameters and can be used for chemical as well as radiological consequence assessments. The code does not model dispersion close to the source (less than 100 meters from the source).

The dispersion model in the ARCON96 code is used for distances close to the release point. ARCON96 empirically accounts for building wake effects occurring under all meteorological conditions and plume meander, which occurs during light-wind stable conditions. It is the only model that is available that accounts for both the vertical and horizontal components of building wake effects and the effects of plume meander. Plume meander occurs under very stable light wind speed conditions (e.g., F stability class with wind speed of 2.2 meters/second). The magnitude of plume meander decreases with distance from the release, higher wind speeds, and more unstable conditions. All of the meander factor decays within 1 kilometer. The building

wake effect also decays as the distance from the release location increases, but it increases with wind speed and more unstable conditions. The faster the wind speed, the larger the aerodynamic effect on the wind field of the building structure.

8.3.4 Concentration Limits

Chemical concentration limits are required to be established to evaluate the potential consequences to the public and to workers for an accidental release of chemicals. Three levels, High (H), Intermediate (I), and Low (L), based on 10 CFR §70.61, are used to define these limits.

Limits are based on Acute Exposure Guideline Level (AEGL) values and Emergency Response Planning Guideline (ERPG) values. Since AEGL and ERPG values are not established for all MFFF chemicals, Temporary Emergency Exposure Limits (TEELs) have been adopted for use in chemical consequence analysis. TEELs were adopted by the U.S. Department of Energy (DOE) Subcommittee on Consequence Assessment and Protective Action (SCAPA). The SCAPA-approved methodology was used to obtain hierarchy-derived TEELs.

The original TEEL methodology used only hierarchies of published concentration limits (i.e., Permissible Exposure Levels [PELs] or Threshold Limit Values – Time-Weighted Averages [TLV-TWAs], Short-Term Exposure Levels [STELs], and Immediately Dangerous to Life and Health [IDLH] values) to provide estimated values approximating ERPGs. The expanded method for deriving TEELs also includes published toxicity data (TD_{LO} , TC_{LO} , LD_{50} , LC_{50} , LD_{LO} , and LC_{LO}). Hierarchy-based values take precedence over toxicity-based values, and human toxicity is preferred to animal toxicity data. Subsequently, default assumptions based on statistical correlation of ERPGs at different levels (e.g., ratios of ERPG-3s to ERPG-2s) were used to calculate TEELs where there were gaps in the data. The TEEL hierarchy/toxicity methodology was used to develop community exposure limits for over 1,200 chemicals to date. The following are the TEEL definitions:

- **TEEL-0** – The threshold concentration below which most people will experience no appreciable risk of health effects.
- **TEEL-1** – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
- **TEEL-2** – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- **TEEL-3** – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

TEEL values for MFFF chemicals are listed in Table 8-5.

As identified in Section 11.4.2.7.4, each emergency control room air intake is continuously monitored for hazardous chemicals. Monitoring will be performed for those chemicals whose unmitigated release could result in control room concentrations above the Immediately Dangerous to Life and Health [IDLH] limit. IDLH values for MFFF chemicals, as available are listed in Table 8-5a.

Note that when a TEEL-3 value is less than an IDLH value for a given chemical, the TEEL-3 limit will be applied. For a chemical with no IDLH value, a TEEL-2 limit will be applied. Table 8-5a contains all the chemical limits used for the control room consequence assessment and provides the source for the specified limits.

Emergency actions will be initiated prior to reaching the chemical consequence concentration limits. Specific set-points will be determined during final design.

Chemical consequence categories for comparison to 10 CFR §70.61 are provided in Table 8-6.

8.4 CHEMICAL ACCIDENT CONSEQUENCES

8.4.1 Analysis

Consequence analysis follows the guidance found in NUREG/CR-6410. Conservatism is embedded in the source term and the ground-level release models.

The analysis to determine the effects at the CAB to the public is based on the following assumptions:

- A wind speed of 2.2 meters per second and F stability class, indicative of 95% "worst-case" meteorological conditions at SRS;

Note: The 95% wind speed of 2.2 meters per second was calculated from the 95% χ/Q value from the ground-level release application of the ARCON96 code applied at a distance of 100 meters. The ARCON96 code was driven by five years of hourly SRS meteorological data. The calculation assumes an F-stability class to quantify σ_y and σ_z . The 100-meter distance is selected because it represents the site worker location. This technique yields a site-specific 5% meteorological condition (F stability class @ 2.2 m/second wind-speed) that is more applicable than adopting the 40 CFR §68.22 meteorology, which is generalized for the entire United States.

- A wind direction that transports the puff kernel and/or plume centerline directly over the receptor of concern (conservative), thereby eliminating any crosswind dispersion;
- An ambient temperature of 25°C (77°F) and 50 percent humidity; representative of late-spring to early-autumn conditions;
- A ground level release (conservative);
- No mechanical or buoyancy plume rise (conservative);

- A rural (i.e., flat terrain) topography (conservative);

Note: The forest canopy morphology at SRS is more accurately characterized as urban terrain relative to atmospheric turbulence intensity.

- Neutrally buoyant gas model (conservative).

Note: Heavy gas models result in lower downwind concentrations, which are less conservative. This is due to density differences (e.g., Colenbrader model within ALOHA) that entrain clean air within the sides of the pancake-like dense gas plume.

These bounding assumptions envelop uncertainties inherent in realistic analyses.

Data in Tables 8-2a through 8-2d were used to perform chemical consequence analyses associated with the largest credible unmitigated spill or loss of containment accident involving each of these chemicals. Airborne concentrations were calculated at distances correlating to the site worker (100 meters) and members of the public (CAB). These concentrations were then compared to the TEELs presented in Table 8-5. From this comparison, a consequence category was established (low, intermediate, high) using the guidance outlined in Table 8-6. These consequence categories correspond to those identified in 10 CFR §70.61.

It should be noted that for the chemicals identified in Tables 8-2a through 8-2d whose onsite inventory is not yet established or is based on preliminary data, the analysis is based on a conservative projection for that chemical. Nonhazardous chemicals and gases identified in Table 8-2d were not evaluated. Except for oxygen, exposure to these gases poses an asphyxiant hazard only. Gas concentrations at asphyxiation levels are not credible at the distances corresponding to the CAB. Gas concentrations at asphyxiation levels may be credible for very large leaks at the distance corresponding to the site worker. Oxygen has no established toxicity limit.

Results of the chemical consequences calculation indicate that for all chemicals to which the requirements of 10 CFR §70.61 apply, unmitigated consequence categories fall within the acceptable range for site workers and members of the public, with the exception of those releases described in Section 5.5.2.10.6.3. Thus, no principal SSCs are required for the protection of site workers and members of the public, except as identified in Section 5.5.2.10.6.3.

Nitric acid leaks or spills in the Aqueous Polishing area of the MFFF were also modeled at temperatures up to the boiling point of nitric acid. The evaporation rate of the nitric acid was calculated utilizing an indoor wind speed of approximately 0.01 meters/second. The consequences of these nitric acid leaks or spills over the full range of temperatures were calculated to be low for the site worker and members of the public.

Uranium dioxide powder releases from the Secured Warehouse, including evaluations of fire and seismic events, are calculated to be low consequence events for the site worker and members of the public. More detailed analyses based on final design and operations are in progress to confirm the results for the site worker. If features such as combustible load controls are required to meet the criteria for the site worker, the features will be identified as IROFS in the ISA.

For the facility worker, the chemical consequences are estimated to be low, except as identified in Section 5.5.2.10. Calculations will be performed for the ISA to confirm this estimate. Principal SSCs have been defined for radiological events, and these SSCs are expected to be applicable to process units where chemicals mix with radiological material, except as identified in Section 5.5.2.10. Furthermore, for chemical exposures that could affect the facility worker in performing a required safety function in the Emergency Control Room, the Emergency Control Room Air Conditioning System is identified as a principal SSC (see Section 5.5.2.10). In the unlikely event that the ISA performed as part of detailed design identifies events that are not bounded, additional SSCs will be identified to ensure that chemical risks are acceptable. Latent Impacts

8.4.2 Latent Impacts

There are no residual, long-term impacts to facility workers, site workers or the public that could result from an acute chemical exposure to licensed material or hazardous chemicals produced from licensed material. There are only two "potential carcinogens" at MFFF (i.e., chemicals on the list of "potential carcinogens"). The two chemicals are hydrazine and uranium (soluble and insoluble). Plutonium and other radionuclides may have carcinogenic effects; however, plutonium and other radionuclides are addressed in section 5.5.

For evaluating site workers exposed to a chemical release, the calculated concentration of an airborne chemical at 100 meters is compared to a TEEL-2 value. For evaluating the public exposed to a chemical release, the calculated concentration of an airborne chemical at the controlled area boundary is compared to a TEEL-1 value.

The TEEL determination process considers latent health effects (i.e., cancer). The determination process (for TEEL-2 and TEEL-3 values) selects hierarchy-based values first, if available, followed by toxicity-based values. TEEL-2 values are based on Emergency Response Planning Guideline (ERPG-2) values when available, or on Permissible Exposure Limits (PEL), Threshold Limit Values (TLV), or Recommended Exposure Limit (REL) ceiling (C) values, or on 5 x TLV-Time Weighted Average (TWA) values, in order of availability, followed by toxicity-based values. TEEL-2 values, along with ERPG, PEL, TLV, or REL ceiling (C) values, take into account latent health effects (i.e., cancer) where appropriate. TEEL-3 values are based on Emergency Response Planning Guideline (ERPG-3) values when available or on Immediately Dangerous to Life and Health (IDLH) values, in order of availability, followed by toxicity-based values. Since the ERPG committee considers latent health effects, TEEL-3 values also take into account latent health effects (i.e., cancer) where appropriate. TEEL-1 values are less than or equal to TEEL-2 values and ensure that exposures do not result in latent health effects.

Therefore, by using the TEEL values as limits, the chemical consequence analysis has taken into account latent health effects (i.e., cancer) from the two potential carcinogens at MFFF.

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gravitational forces producing convection in this phase. Downward heat transfer between the phases, therefore, involves conduction, rather than convection, and heat removal is consequently lower. This description represents the limiting system from the perspective of selecting a minimum initiation temperature for a runaway reaction.

DCS has selected a design basis temperature of 133°C to limit the heat generation rate. This design basis temperature is based on the experimentally determined minimum initiation temperature for a *closed* system and is derived from isothermal experimental conditions. Furthermore, selection of this design basis temperature ensures that the selected diluent (discussed below) will not undergo degradation and lower the minimum initiation temperature of a runaway reaction.

Based on experimental evidence, the exclusion of cyclic chain hydrocarbons in diluents indicates that temperatures far in excess of 133°C are necessary to initiate runaway reactions in *open* systems containing nitric acid. Experimental evidence also suggests that diluents containing a large fraction of cyclic hydrocarbons (i.e., ~20—30% naphthenes) undergo significant nitration at temperatures lower than corresponding systems composed of both TBP and diluent. Therefore, the nature of the diluent is relevant in establishing the temperature at which systems composed of TBP/diluent begin to “run away.” The use of C₁₀-C₁₃ branched chain hydrocarbons (aliphatic diluent HPT) in the AP process optimizes both the plutonium decontamination factor and the nitration resistance to ensure an adequate safety margin associated with the operation of the process. Consequently, DCS has identified the properties of the diluent as the safety function of the chemical safety control principal SSC. The design basis for this chemical safety control principal SSC is to utilize a diluent that does not contain cyclic chain hydrocarbons.

DCS has also identified the offgas treatment system as a principal SSC. The safety function of the offgas treatment system is to provide venting of vessels/equipment that may potentially contain TBP and its associated by-products to prevent over-pressurization in the case of excessive oxidation of TBP and/or its degradation products. The design basis value for this principal SSC is selected to be consistent with experimental results (e.g., 8×10^{-3} mm²/g of organic). The use of venting implies control of the bulk quantity of organics that may be present in a given vessel. However, for the majority of vessels DCS has limited the volume of the vessel so as to not require this limitation (i.e., tanks are considered full of organics and hence, no limitation of organic content is necessary). Note that as an additional protection feature, DCS has implemented the following features to preclude the transfer of bulk quantities of organic to heated equipment:

- A diluent washing pulsed column for washing the extracted plutonium aqueous stream
- A diluent washing pulsed column for washing the extraction process unloaded feeding solution (“raffinates stream”)
- A diluent washing mixer-settler for washing the extracted uranium aqueous stream
- A diluent washing mixer-settler for washing the aqueous phase containing TBP degradation products from solvent recovery.

In those few cases where the vent area to mass ratio is not satisfied, the offgas treatment system is still credited as a principal SSC. However, in this case the safety function of this principal SSC is to provide an exhaust path for aqueous phase evaporative cooling in process vessels,

thereby providing a mechanism for heat removal. This implies that the required venting for mass transfer is much less than that required for pressure relief during a "runaway" reaction. This principal SSC is utilized in conjunction with the process safety control subsystem to ensure that the rate of energy generation does not exceed the rate of heat removal. Thus, the design basis of the offgas treatment system for this case is to relieve 1.2 times the combination of energy generation and energy input to the system. This safety function of the offgas treatment system is the primary means for satisfying the performance requirements of 10 CFR 70.61.

In addition, because gases are released during the chemical reactions, foaming may be possible. Foaming in the organic phase occurs as self-heating accelerates due to the gases generated. Significant amounts of foam could limit the effectiveness of the vent. In addition, foam can be thermally isolated from the rest of the system because of its insulating qualities. A foaming mass that is undergoing an exothermic reaction may therefore attain a higher temperature than a liquid in contact with a heat sink, such as water. When a cyclic diluent was utilized in past red oil incidents, foaming is believed to have occurred prior to a runaway condition. Again, the selection of a diluent containing no cyclic hydrocarbons and limitations on the temperature are implemented as principal SSCs to limit foaming and provide reasonable assurance that the vents remain effective.

8.5.1.5.6 Impact of Tomsk-7 Event

On April 6, 1993, at the Tomsk-7 nuclear fuel processing facility located in Siberia, Russia, there reportedly were two sequential explosions that caused physical damage to the facility and contaminated the facility and the surrounding area. The explosions appear to be due to the "red oil" phenomenon associated with nitric acid, TBP, and the hydrocarbon diluent used by the Russians, and was initiated by actions that constituted violations to operating procedures and operating conditions unlikely to occur at the MFFF. Inadequate venting was also a likely contributor in the explosion.

The Tomsk-7 event identified a new mechanism to the TBP degradation/red oil formation phenomenon. This arose from the apparent initiation of an energetic runaway reaction in the vicinity of 90°C, far below the previously observed minimum temperature for a runaway TBP hydrolysis-limited reaction. Several investigators postulated that the accumulation of two degradation products, butanol and butyl nitrate, may have been responsible for the lower initiation temperature. Experimental results have verified that these two degradation products of TBP can, in the presence of concentrated nitric acid, release significant energy at temperatures far less than 133°C. Significant buildup of degraded organics is not expected at the MFFF (i.e., solvent is routinely used and regenerated as part of normal operations, and most degraded organics are destroyed during normal operation). Nonetheless, such a buildup is conservatively postulated.

Butanol, a TBP degradation product, is rapidly and completely converted to butyl nitrate at temperatures of 110°C to 120°C, and is oxidized further to butyric acid, propionic acid, and acetic acid when contacted with moderate to strong (6M to 15.8M) nitric acid. Butyl nitrate oxidation begins as solutions with 10M to 15.8M nitric acid are heated to between 52°C and 85°C, and these reactions are strongly exothermic. The heat of reaction for butanol oxidation has been determined to be -466 cal/g (-1948 J/g) of butanol based on a 1:1 butanol to nitric acid

ratio. The negative heat of reaction favors the formation of butyl nitrate in this reaction equilibrium. Additional experimental results indicate that even at a fairly low concentration of nitric acid (0.8M), butanol is converted to butyl nitrate at about 100°C.

Thus, in order to determine whether the accumulation of TBP degradation products butanol and butyl nitrate can provide the initial energy release via oxidation to raise the organic phase temperature to above 133°C, a determination of the quantity of each species in solution must be obtained (unlike the pre-Tomsk-7 operating assumption that, in the formulation of a model to describe TBP degradation at elevated temperatures, the oxidation reactions proceeded much more rapidly than the hydrolysis reaction and consequently degradation products did not build up).

To determine the quantity of degraded organics necessary to raise the temperature of the bulk organic to 133°C, the minimum initiation temperature for a runaway reaction, the total quantity of organic necessary support a runaway reaction in an open system is calculated utilizing the vent-to-organic-mass ratio described above. A heat balance is then utilized to calculate the quantity degraded organic necessary to elevate the bulk organic temperature to 133°C.

Preliminary analyses have indicated that the organic mass in a vessel or tank must be limited to on the order of 30 kg of organic material. Based on conditions that could be encountered during unlikely extended shutdowns, the mass of degraded organics necessary to elevate the bulk organic temperature to the 133°C is a few kilograms. The total degraded organic/TBP mass is given by the production rates from both radiolysis and hydrolysis minus the amount of degraded organic lost to the system from evaporation and oxidation via the nitric acid. These preliminary analyses indicate the degraded mass is reached in on the order of years. Consequently, the principal SSCs are established to provide reasonable assurance that significant quantities of butanol and/or butyl nitrate do not build up in the process. The design basis for these controls is limiting the residence time of organics in the presence of oxidizers such as nitric acid (i.e., in process vessels containing oxidizing agents and potentially exposed to high temperatures), and radiation fields, to limit the quantity of degraded organics that may buildup in the system either through hydrolysis and/or radiolysis.

8.5.1.6 Pyrophoricity of Uranium and Plutonium

Both plutonium and uranium metals are pyrophoric and readily ignitable when existing in a finely divided form. When these metals are present in large or massive forms they do not present a significant fire risk. When these metals exist in the dioxide form (e.g., PuO_2 and UO_2) they are relatively stable and not considered pyrophoric. The MFFF only handles these materials in the dioxide form.

While the fire risk associated with the dioxide forms of U and Pu is low, hazards associated with handling of these materials do exist. Uranium dioxide can undergo further oxidation to higher oxides resulting in spontaneous heating. Sub-stoichiometric plutonium oxides formed by incomplete or partial oxidation of plutonium metal can be pyrophoric. These hazards are described below.

8.5.1.6.1 UO_2

At elevated temperatures, finely divided UO_2 can undergo further oxidation to higher uranium oxides, specifically U_3O_8 . This reaction results in spontaneous heating of the oxide and is typically referred to as "burnback." In the past, this phenomenon has been associated with fires at fuel fabrication facilities handling UO_2 . In these events, the oxidizing uranium powder was believed to be heated by some mechanical failure (i.e., friction) which initiated the burnback reaction and released heat. Combustible materials such as transfer hoses and boots then provided the fuel to support a fire.

In addressing this hazard, the SA has identified UO_2 spontaneous heating as a cause for fire in a glovebox. Also, the heat generated by the burnback phenomenon has been considered in the thermal analysis of facility gloveboxes as described in Section 5.5.2.1.6.9. The specific power of UO_2 oxidation is taken into account using the following design basis values:

- If $T < 74^\circ\text{C}$ (165.2°F) then $P_{\text{ox}} = 0$ W/kg (0 W/lb) of UO_2 ,
- If 74°C (165.2°F) $< T < 340^\circ\text{C}$ (644°F) then $P_{\text{ox}} = 1.1$ W/kg (0.499 W/lb) of UO_2 ,
- If $T > 340^\circ\text{C}$ (644°F) then $P_{\text{ox}} = 4.63$ W/kg (2.1 W/lb) of UO_2

where T is the powder temperature.

Although not identified as principal SSCs to address this specific hazard, the following features of the UO_2 storage/handling processes provide additional protection:

- UO_2 delivered to the MFFF site and stored in steel drums, double bagged under a N_2 atmosphere
- UO_2 maintained in a N_2 atmosphere throughout the process
- Fire detection and suppression systems provided for gloveboxes (CO_2 injection) and process rooms (clean agent)
- Use of noncombustible or nonflammable materials for process equipment construction and furnishing

important parameter that limits the quantity of hydrazoic acid in the system. The yield of hydrazoic acid from the reaction between hydrazine and nitrous acid is determined predominately by both the relative reaction rates of the nitrous acid reaction with hydrazine and hydrazoic acid, and the concentration of hydrazine present in the system, which is added to the Purification Cycle at 0.14 mol/L. A yield of 39.3% or less is necessary (0.055/0.14) to ensure limiting conditions are not present in the AP processes.

Thus, the design basis to control the risk related to hydrazoic acid explosions is as follows: ensure the hydrazoic acid yield is 39.3% or lower, ensure a maximum hydrazine concentration of 0.14 moles per liter is used; and ensure a maximum temperature of 60°C where these chemicals are used in the AP process. DCS will perform analysis in the ISA to establish a bounding hydrazoic acid yield and implement any necessary controls to ensure that the hydrazoic yield is below 39.3%, which ensures that the critical concentration of 0.055 mol/L of hydrazoic acid is not exceeded.

It should be noted that that the corresponding limitations on the hydrazoic acid yield assume adiabatic conditions. DCS is currently investigating more realistic heat transfer that may be utilized in the ISA to justify the use of a larger threshold partial pressure (i.e., greater than 19 Torr, which is the theoretically calculated partial pressure of hydrazoic acid).

In addition to the previously identified design basis, sampling controls are also implemented to ensure that the process of transforming the hydrazoic acid to sodium azide within the Solvent Recovery Unit is effective to ensure that hydrazoic acid does not accumulate in the process to a limiting concentration due to the continuous injection of hydrazine into the Purification Cycle. This sampling control also ensures that azides are not formed within the extraction and diluent washing pulse columns of the Purification Cycle (i.e., PULS2000 and PULS2200) due to the potential presence of metal impurities within these columns.

An additional case involves the evaporation of hydrazoic acid in solution at low temperatures (e.g., approximately 20°C) and subsequent condensation of the hydrazoic acid in the ventilation system. In this case, it is theoretically possible to reach a limiting for the hydrazoic acid concentration to reach the explosive threshold in the condensing aqueous solution of 0.055 mol/L (limiting value based on theoretical threshold partial pressure). At higher temperatures (i.e., greater than approximately 20°C), the gaseous phase contains sufficient water vapor to ensure that if any vapor is condensed, limiting concentrations of hydrazoic acid cannot be obtained. The partial pressure of hydrazoic acid will be dramatically reduced, however due to the dilution in the ventilation system; further unrealistically low temperatures would need to be present in the ventilation system in order for hydrazoic acid condensation to occur. Consequently, DCS will perform additional analyses during the ISA to determine if any additional controls are necessary to preclude the condensation of hydrazoic acid inside the ventilation system.

8.5.1.9 Metal Azides

The azide anion, N_3 forms adducts with metallic cations. Metal azides, formed in basic media from metallic cations and hydrazoic acid interaction, are slightly soluble to non-soluble (e.g., Ag or Zr) in aqueous media. Characteristics of the bond between the anion and the cation, which

form the azide salt, can cause these compounds to become unstable under specific conditions. The most unstable azide salts are the heavy metallic salts that form covalent bonds with N_3^- .

Most azides in pure chemical form decompose when heated. Azide salts are thus not stable when placed in dry conditions at temperatures far above 133°C. With the exception of the calcining furnace, this is the limiting temperature within the AP Process.

With the exception of hydrazoic acid, the AP process precludes any significant production of azides. This is accomplished by the removal of a significant fraction of the impurities in the plutonium feedstock introduced into the front end of the Purification Cycle (i.e., into the extraction pulse column, PULS2000) and by the absence of hydrazoic acid from the columns and tanks that may contain these impurities. The absence of hydrazoic acid from the front end of the Purification Cycle is assured due to sampling controls whose function is to detect hydrazoic acid prior to reintroducing solutions into the front end of the Purification Cycle (e.g., TK1000 or PULS2000).

In the plutonium stripping pulsed column (PULS3000) and equipment downstream of this column, hydrazoic acid is present due to the introduction of hydrazine into the plutonium barrier mixer-settler (MIXS4000) which feeds PULS3000 and subsequent downstream equipment. In the event that metal azides are formed within this Purification Cycle equipment, the azides will reside in the aqueous phase which is introduced into the oxidation column (CLMN6000) within the Purification Cycle prior to transfer to a downstream unit. Within the oxidation column, the azides will be destroyed due to the presence of nitrous acid which reacts with the azide to produce a nitrogen gas.

Finally, prior to being introduced into the calcining furnace, the solution is sampled to further ensure that azides are not introduced into the furnace whose temperature may exceed 140°C. This sampling measurement which ensures that azides are not present is identified as a principal SSC. In addition, the Process Safety Control Subsystem is also identified as a principal SSC to ensure that equipment potentially containing azides are not exposed or raised to temperatures that could exceed 133°C.

As discussed previously, azides in a dry environment are also unstable with respect to shocks due to the weak intermolecular force holding the azide together. Consequently, to ensure that conditions do not exist to create this potential hazard, administrative controls have been identified as the principal SSC to ensure that tanks potentially containing azides are not left dry. Previously identified process controls and the sampling controls to limit the presence of hydrazoic acid in process vessels are also used to preclude this potential explosion event.

Additional details on specific azides that could potentially be formed within the AP Process are provided below.

Plutonium and Uranium Azides

The azide anion can form soluble weakly bonded azido complexes with uranium (U) and plutonium (Pu) at molar ratios of HN_3/Pu and HN_3/U less than one. Considering that the bounding hydrazoic acid (HN_3) concentration developed in the previous section is 0.055 mol/L,

Table 8-5. TEELs Used as Chemical Limits for Chemicals at the MFFF (Note 1) (continued)
(mg/m³)

Name	TEEL-1	TEEL-2	TEEL-3
Sulfuric Acid	2	10	30
Sulfamic Acid	40	250	500
Thenoyl TrifluoroAcetone	3.5	25	125
Tributyl Phosphate	6	10	300
Uranium Dioxide	0.6	1	10
Uranyl Nitrate	1	1	10
Xylene	600	750	4000
Zinc Stearate	30	50	400
Zirconium nitrate	35	35	50

Table 8-5 Notes:

1. Temporary Emergency Exposure Limits (TEELs), Revision 18, are derived from approved methodologies developed by Department of Energy Subcommittee on Consequence Assessment & Protective Actions (SCAPA) and are identified in WSMS-SAE-02-0001.

Table 8-5a. Chemical Limits Used for Control Room Consequence Calculations at the MFFF (mg/m³)

Name	Concentration Limit (mg/m ³)	Source of Limit
Aluminum Nitrate	15	TEEL-2
Azodicarbonamide	500	TEEL-2
Chromic (III) Acid	25 mg Cr (III)/m ³	IDLH
Chlorine	29	IDLH
Diluent (C10-C13 Isoalkanes)	35	TEEL-2
Ferrous sulfate	12.5	TEEL-2
Fluorine	30	TEEL-3
Hydrazine Monohydrate	0.06	TEEL-2
Hydrazine Nitrate	5	TEEL-2
Hydrofluoric Acid	25	IDLH
Hydrochloric Acid	75	IDLH
Hydrogen Peroxide	106	IDLH
Hydroxylamine Nitrate	26	TEEL-2
Iron	500	TEEL-3
Isopropanol	5000	IDLH
Manganese Nitrate	500 mg Mn/m ³	IDLH
Manganous Sulfate	500 mg Mn/m ³	IDLH
Nitric Acid	66	IDLH
Nitric Oxide	125	IDLH
Nitrogen Dioxide	35	TEEL-3
Nitrogen Tetroxide	15	TEEL-2
Oxalic Acid	500 mg/m ³	IDLH
Potassium Permanganate	15	TEEL-2
Silver Nitrate	10 mg Ag/m ³	IDLH
Silver Oxide	10 mg Ag/m ³	IDLH
Sodium	5	TEEL-2
Sodium Carbonate	50	TEEL-2
Sodium Hydroxide	10 mg/m ³	IDLH
Sodium Nitrite	1	TEEL-2

Table 8-5a. Chemical Limits Used for Control Room Consequence Calculations at the MFFF (mg/m³) (continued)

Name	Concentration Limit (mg/m³)	Source of Limit
Sulfuric Acid	15 mg/m ³	IDLH
Sulfamic Acid	250	TEEL-2
Thenoyl TrifluoroAcetone	25	TEEL-2
Tributyl Phosphate	300	TEEL-3
Uranium Dioxide	10 mg U/m ³	IDLH
Uranyl Nitrate	10 mg U/m ³	IDLH
Xylene	3900	IDLH
Zinc Stearate	50	TEEL-2
Zirconium nitrate	10 mg Zr/m ³	IDLH

Table 8-6. Application of Chemical Limits to Qualitative Chemical Consequence Categories

Consequence Category	Worker	Public
High	Concentration \geq TEEL-3	Concentration \geq TEEL-2
Intermediate	TEEL-3 > Concentration \geq TEEL-2	TEEL-2 > Concentration \geq TEEL-1
Low	TEEL-2 > Concentration	TEEL-1 > Concentration

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A seismic monitoring system is included in the design of the MFFF. The system is designed to satisfy the criteria provided in Regulatory Guide 3.17-1974, *Earthquake Instrumentation for Fuel Reprocessing Plants*. The monitoring system will activate the seismic isolation system at a setpoint of one-third of the design basis earthquake based upon the criteria of 10 CFR 50 Appendix S, IV(a)(2)(i)(A).

Combustible (i.e., hydrogen) gas detectors will be selected in accordance with ISA-12.13-Part I-1995 *Performance Requirements for Combustible Gas Detectors*. Installation, operation and maintenance of combustible gas detectors will be in accordance with ISA RP12.13-Part II-1987 *Installation, Operation, and Maintenance of Combustible Gas Detection Instruments*.

The design basis for the process safety control subsystem is overcurrent/overvoltage protection in accordance with NFPA 70 (National Electrical Code) 210-20 (Over Current Protection), 240-12 (Electrical System Coordination) and 240-13 (Ground Fault Protection of Equipment). Specific setpoints will be established consistent with the requirements of the ISA.

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Enclosure 3

Revised Response to DSER Open Item AP-03

Enclosure 3
Revised Response to DSER Open Item AP-3

Open Item AP-03:

The applicant's hazard and accident analysis did not include events involving titanium, such as titanium fires. Accident events should be evaluated and PSSCs identified as necessary. This applies to the dissolution unit (DSER Sections 11.2.1.3.4)

Response:

DCS amends the response in our letter dated 23 May 2003 to update the PSSCs to ensure titanium fires do not occur at the MFFF. The PSSCs are:

- Administrative controls associated with isolation of power to the electrolyzer when the electrolyzer is drained
- The process safety control subsystem

The design basis for the process safety control subsystem is overcurrent/overvoltage protection in accordance with NFPA 70 (National Electrical Code) 210-20 (Over Current Protection), 240-12 (Electrical System Coordination) and 240-13 (Ground Fault Protection of Equipment). In addition, DCS did review IEEE 242 regarding over current/voltage protection and verified that the National Electrical Code (NFPA 70) was more applicable for small loads. Specific trip setpoints will be established as part of the ISA.

Action:

Update the CAR to include the PSSCs identified above and the associated safety functions.